Top Dilepton Cross-Section Measurement -Full Status Report-

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Overview

- Review of the Analysis
- Changes from the LP'2003 Blessed Measurement
- Signal Acceptance and Backgrounds
- Systematic Uncertainties
- Candidate Events
- New Cross Section Result
- Future Plans

Documentation

- Related CDF Notes:
  - CDF6830- "Measurement of the tt xsection with dileptons" **– new**
  - CDF6590- "Acceptance and Background Systematics" **-updated**
  - CDF6742- "A 2nd Determination of the Fake Background" **- updated**
  - CDF6517- "Adding CMIO muons to the Top Dilepton xsection"
  - CDF6579- "Optimization studies for the Top Dilepton xsection"
  - CDF6591- "Determination of DY background-Summer'03"
  - CDF6592- "Fake Lepton Backgrounds for the Summer'03"
  - CDF6588- "A measurement of the tt xsection – Summer'03 "
- Q&A web page in place
- Previous talks at this meeting
  - **Andy Hocker**, "Dilepton Cross Section Update", 08-JAN-2004
- Many updates at Dilepton meetings (see WebTalks)

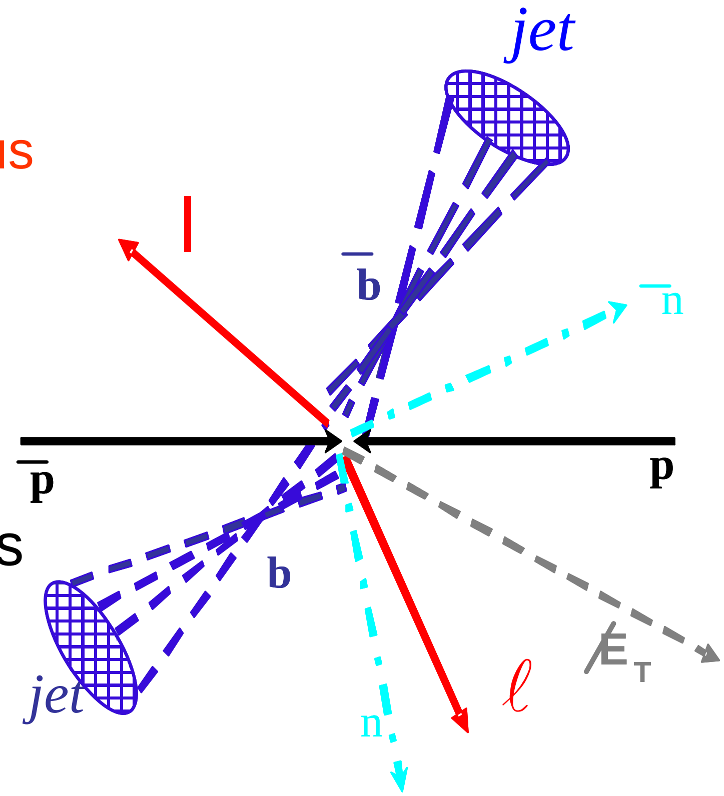
History of the analysis

- We started in Fall'02
  - blessed the measurement with 72 pb^{-1} in Spring'03 using tight-tight dilepton categories
- Performed various optimizations
  - doubled the acceptance for LP'03 blessed result
- This is the third iteration
  - incorporating the lessons from the previous two
  - use the full dataset available until September 2003 shutdown

Top Dilepton Topology

- 2 high-E_T, leptons (e, μ)
  - Sensitive only to leptonic decays of taus
  - Loose nonisolated leptons allowed
- Large missing energy E_T
  - Corrected for muons and tight L5 jets
- Z-mass region for same-flavour events
  - special treatment
- At least 2 jets with large E_T
  - Cone algorithm 0.4
  - Corrected E_T to L5, $|\eta| < 2.5$
- Large transverse energy flow

  $H_T = \Sigma(E_T^{leptons}, E_T^{jets}, MET)$



Changes from Summer'03

- Revisited the lepton categories (See Andy's Talk)
  - Excluded Non-PHX PEMs
    - Big bckgr source: half the fakes, 20% of total bckgr
    - Contributes about 5% to top acceptance
  - Excluded Plug-Plug categories
    - < 2% of top acceptance
    - Come in on MET_PEM trigger, which makes any data-driven DY determination very hard
- Cut on COT exit radius for CMX muons
- PHX $|\eta| < 2.0$ to reduce the charge fake
  - (Summer'03: $|\eta| < 2.5$)
- Updated the scale factors, trigger and reconstruction efficiencies

Event Selection

- $\geq$ 2 leptons, p_T > 20 GeV
  - At least one of which is TIGHT (CEM, CMUP, CMX or PHX)
  - At most one central lepton (except CMIO) can be nonisolated
- $\geq$ 2 jets, L5 corrected, E_T > 15 GeV
- MET > 25 GeV (corrected for muons, jets)
  - If MET < 50 GeV, $\Delta\phi$ (MET, nearest l or j) > 20 deg
- If 76 GeV < M_{ll} < 106 GeV and same-flavor,
  - jetSig > 8 (jetSig=MET/sqrt(Σ jet E_T projected on MET))
  - $\Delta\phi$ (MET, nearest l or j) > 10 deg
- H_T > 200 GeV (H_T=Σ(leps, jets, met))
- Opposite charge

Dilepton categories

ee category	Trigger required
CEM-CEM (1 can be NI)	CEM_18
CEM-PHX (CEM can be NI)	CEM_18

em category	Trigger required
CEM-CMUP (1 can be NI)	CEM_18 || CMUP_18
CEM-CMIO/U/P (U/P can be NI)	CEM_18
CEM-CMX (1 can be NI)	CEM_18 || CMX_18
PHX-CMUP (CMUP can be NI)	CMUP_18
PHX-CMX (CMX can be NI)	CMX_18
PHX-CMIO/U/P (U/P can be NI)	MET_PEM

mm category	Trigger required
CMUP-CMUP (1 can be NI)	CMUP_18
CMUP-CMIO/U/P (U/P can be NI)	CMUP_18
CMX-CMUP (1 can be NI)	CMX_18 || CMUP_18
CMX-CMIO/U/P (U/P can be NI)	CMX_18
CMX-CMX (1 can be NI)	CMX_18

Signal Acceptance

- Use PYTHIA ttopei sample
- Only HEPG dilepton events in numerator
  - tt l+j treated as fakes!
- New:
  - only events with OBSV $|z_v| < 60$ cm in numerator and denominator
  - $|z_0| < 60$ cm cut effic. (0.95) from data (CDF 6660)
- "Raw" acceptance:

$$\boxed{\varepsilon_{raw} = (0.78 \pm 0.009)\ \%}$$

-uncertainty in statistical only

Backgrounds - Overview

- Main sources of backgrounds:
  - Fakes
    - Mainly W+≥3jets, one jet faking a lepton
    - Estimated entirely from data
    - A second technique developed (CDF6592), many checks
    - Reduced by ~60% after the exclusion of PEM leptons
  - Diboson (WW/WZ)
    - Estimated using Monte Carlo
  - Drell-Yan
    - Estimated using Data/MC
    - Normalizations from data
    - Larger MC samples available

Fakes Background

- Used a second method to reduce the systematic uncertainty
- Instead of fake rate per jet, determine fake rate per CdfEmObject and per min-I track
- Fake rate parametrized in bins of E_T and iso
  - Improves predicted-vs.-observed results,
  - Results in larger stat errors on fake rates
- Method documented in CDF 6742
  - Results were consistent with CDF 6592 (LP '03 method)

Fake rates cross-checks

- We use fake rate from JET50
- Apply them to other jet samples
  - JET20, JET70, JET100, b enriched
- Good agreement between predictions and observed fakes
- Non-isolated leptons also show good agreement

NCEM

	pred	obs
J20	37 +/- 7	34 +/- 6
J70	74 +/- 40	63 +/- 8
J100	63 +/- 190	67 +/- 8
8 GeV μ	27 +/- 7	31 +/- 6
w/ secvtx	3 +/- 2	5 +/- 2

NMUO

	pred	obs
J20	74 +/- 21	72 +/- 8
J70	102 +/- 55	88 +/- 9
J100	150 +/- 300	100 +/- 10
8 GeV e	0 +/- 3	1 +/- 1
w/secvtx	0 +/- 0.5	0

Isolated leptons cross-checks

- Few isolated categories

LMU = {CMU, CMP, CMIO}

PHX

	Pred	obs
J20	53 +/- 8	51 +/- 7
J70	60 +/- 11	75 +/- 9
J100	82 +/- 53	68 +/- 8
8 GeV μ	9 +/- 1	17 +/- 4
w/ secvtx	.7 +/- .1	2 +/- 1

LMUO

	Pred	obs
J20	42 +/- 26	18 +/- 4
J70	36 +/- 12	21 +/ 5
J100	88 +/- 25	50 +/- 7
8 GeV e	6.5 +/- 4	1 +/- 1
w/ secvtx	.4 +/- .5	0

SS test of fakes:

	0 jet	1 jet	2 jet
SS predicted	2.3+/- 0.5	1.8+/-0.4	0.9+/-0.2
SS observed	3	2	0

Drell Yan Background

- Basic idea behind previous iteration's method (CDF6591) used in the Summer03:
  - Scale MC MET tail to data in each jet bin
  - Suffers from poor data statistics per jet bin
  - Now we have smaller eta acceptance for the plug and the data statistics becomes even poorer
    - Only 32% of DY comes from CC categories
- Use an approach similar with lepton+track:
  - Look at data MET tail in all jet bins
  - Use MC to tell you how to distribute data across jet bins

DY background method 1

- Use data:
  - To measure the number of Z's inside the mass window
    - N_{MET} (after MET > 25)
    - N_{zveto} (after MET> 25 and Zveto cuts)
    - Subtract contribution from other processes
- Next use Monte Carlo:
  - to distribute the events in jets bins
    - N_0/N_{tot}, N_1/N_{tot}, $N_{\geq 2}/N_{tot}$
  - to move outside the mass window
    - $R^j_{o/i}$ = ratio of outside/inside for jet bin j
  - to calculate H_t cut efficiency (mass dependent)
    - Inside the mass window
    - Outside the mass window

DY background method 2

MC

Inside:

$$N^{j}_{DY}(in) = (N_j/N_{tot})* N_{Zveto} * \varepsilon_{Ht}$$

DATA

Outside:

$$N^{j}_{DY}(o) = (N_j/N_{tot})*R_{o/i}* N_{MET} * \varepsilon_{Ht}$$

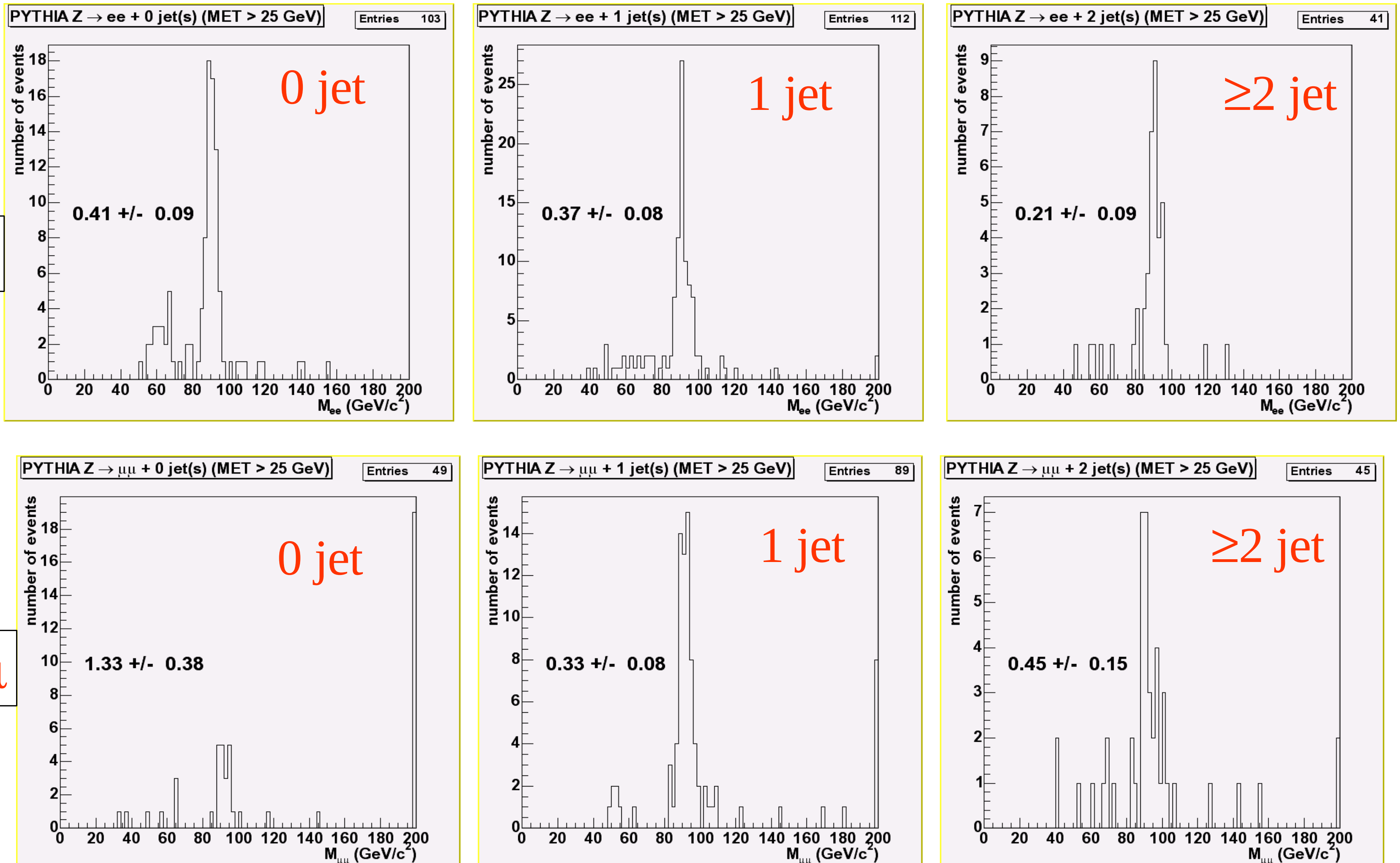
MC

- We estimate DY in each jet bin j, where j=0,1, ≥2
- We want to check our predictions on 0 and 1 jet bin

Drell Yan:$R_{o/i}$

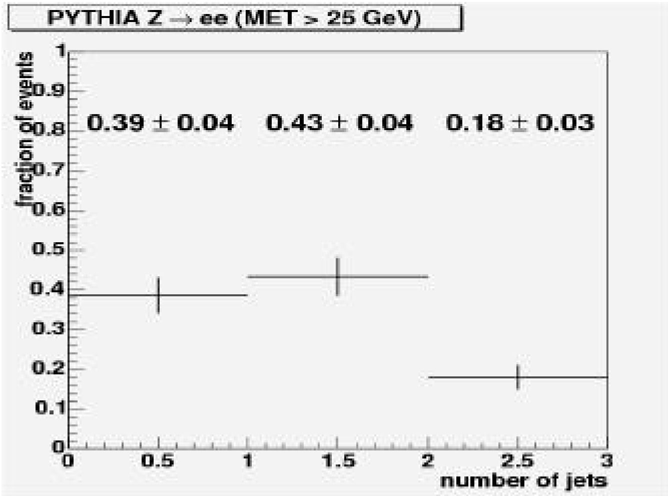
ee

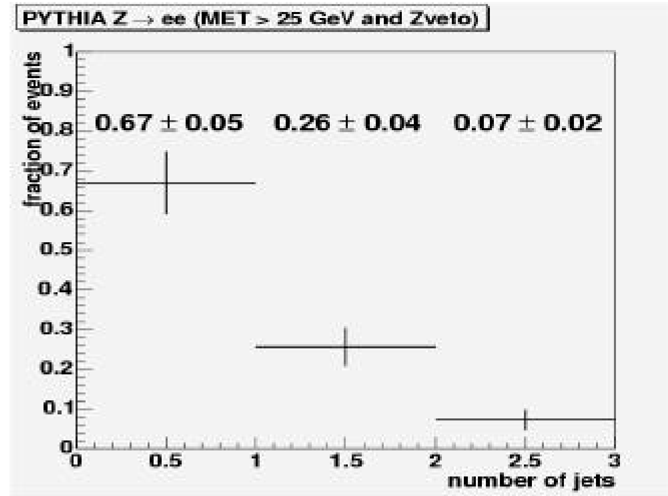
μμ



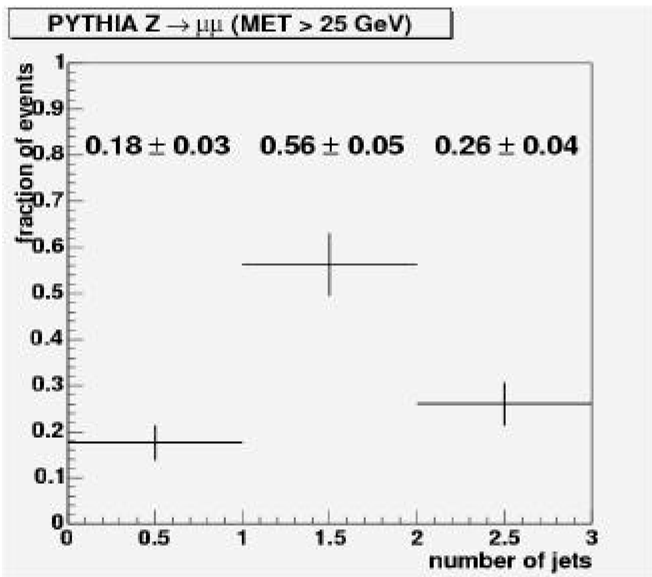
Drell Yan: N jet ratios

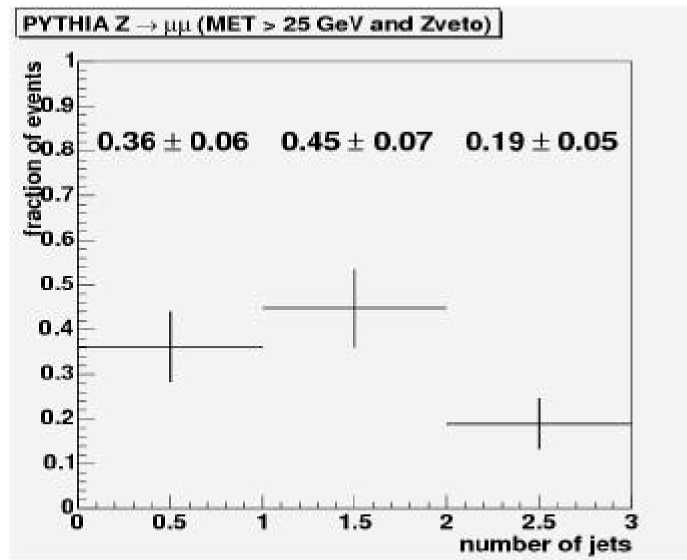
ee





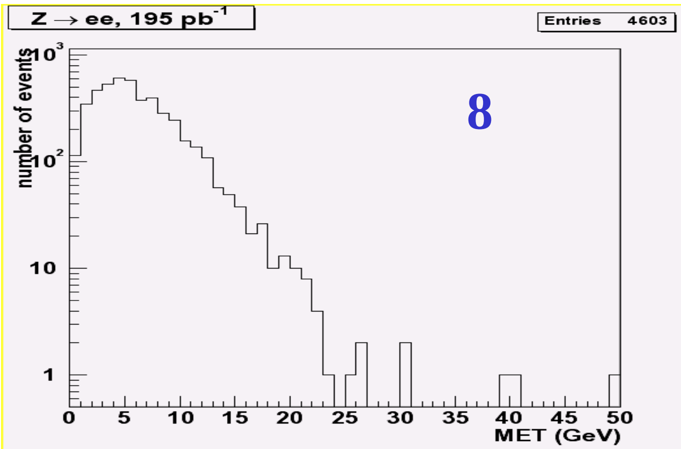
μμ

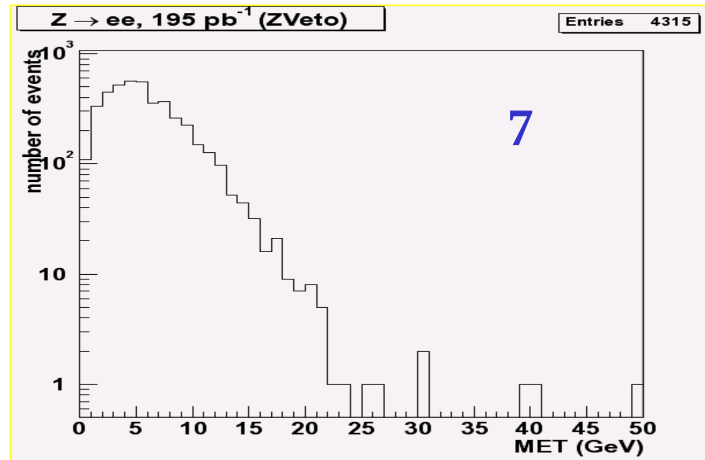


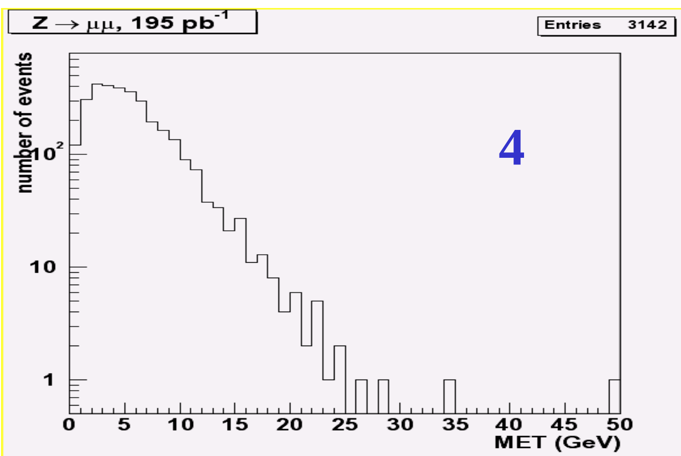


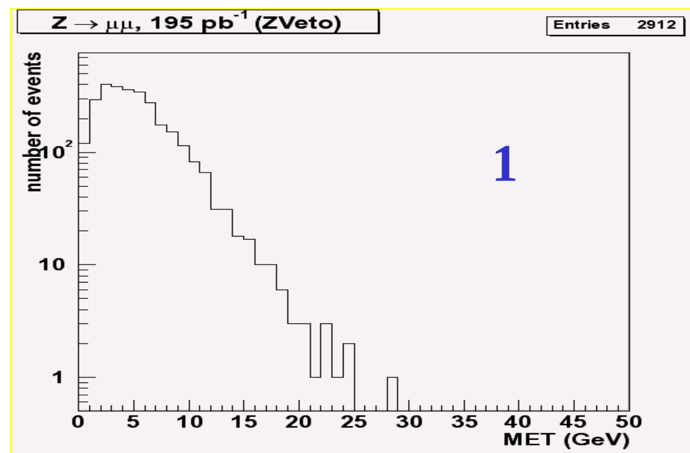
Drell Yan: N_{MET} and N_{Zveto}

- Dominant uncertainty is due to limited number of Z’s after MET and Zveto cuts



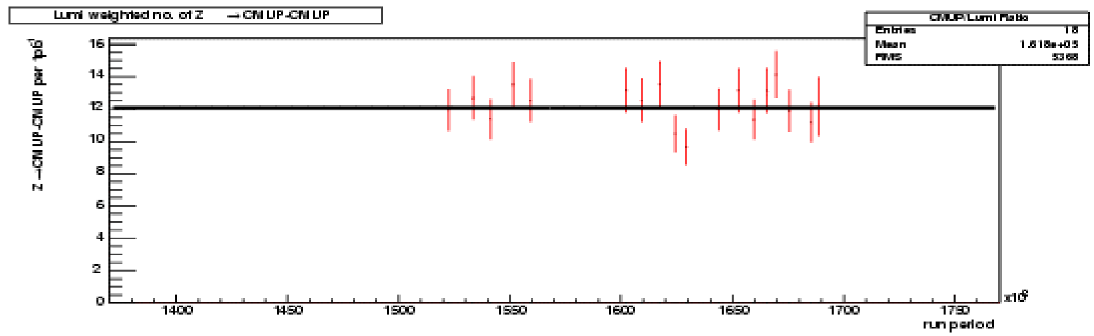


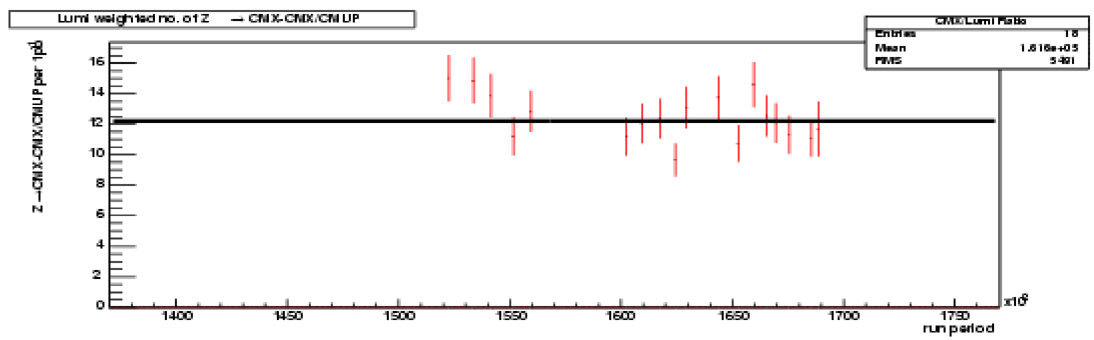




Data validation

- We looked at electron and muon yields over time Z's, W's in central region (Eva H. , M. Tecchio)





- PHX W xsec from plug dataset was checked for LP03 (2.4 nb, see CDF 6588)- plan to check it again

Z cross sections

- Full cross sections
  - the latest scale factors
  - version 4 DQM good run list (162 pb^{-1})
  - for details see CDF 6830
- Results:
  - $Z \rightarrow ee$ (CEM-CEM): 235 +/- 15 pb
  - $Z \rightarrow ee$ (CEM-PHX): 231 +/- 15 pb
  - NNLO: 252 +/- 8.8 pb

Datasets used

- High-P_T lepton datasets, 4.11.1 REMAKE
- Plug dataset (bpel08/09), stripped on L3 MET_PEM, 4.11.1 “REMAKE”
- PES alignment corrections done when ntuplizing data
- Use DQM GRL v4
  - Bad CSL and SVX beamline runs excluded by hand
- We use 4 good runs and luminosities:
  - CEM/CMUP: 193 pb^{-1}
  - CEM/CMUP and CMX: 175 pb^{-1}
  - CEM/CMUP and Si: 162 pb^{-1}
  - CEM/CMUP and Si and CMX: 150 pb^{-1}

Systematics: *Signal Acceptance*

- Jet Energy Scale – shift jet correction by $\pm 1\sigma$ and take half-difference in acceptance
- ISR - take half the difference in acceptance for samples with/without ISR
- FSR - use a different underlying event tunning (tune B)
- PDF – effect on acceptance due to:
  - Different PDF functions (MRST vs CTEQ6M)
  - Different α_s
  - $\pm 1\sigma$ fit parameters within CTEQ6M
- MC generators – compare Herwig with Pythia

Id efficiency SF uncertainty

- There are few possible options we are considering
- Id vs jet bins approach → out of statistics in ≥2 jets
  - Use inclusive SF and assign an uncertainty that covers ≥2 jets bin
  - Use SF for each bin with its uncertainty
- Fold in the id vs iso distribution
  - Most of electrons are very isolated
- Fold in the id eff vs ΔR(electron, closest jet)
  - Again dilepton events are not as jetty as lepton+jets and the overall uncertainty due to id eff smaller
  - l+jets SLT b-tagging analysis: 5%

Systematics - *Signal Acceptance*

- *Same methodology as for Summer'03*
- *Uncertainties re-evaluated (CDF 6590)*

Source	Uncertainty (%)
Lepton ID SF + Trig. Effic.	2.0 *
Jet Energy Scale	4.7
ISR/FSR	1.7
PDF's	11.6
MC Generators (Pythia vs Herwig)	5.5
Total	**14**

Systematics: *Backgrounds*

- Fakes
  - largest difference between the fake background using JET50 fake rates and JET20, JET70 or JET100
- Diboson
  - compare Pythia with Alpgen
- Jet Energy Scale (WW/Z$\rightarrow\tau\tau$)
  - shift jet correction by $\pm 1\sigma$ and take half-difference in acceptance
- Drell-Yan
  - changing the energy scale up/down $\pm 1\sigma$ we derive a systematic uncertainty on H_t cut
  - 2 jet scale factor uncertainty

Systematic Uncertainties: *Backgrounds*

Background	Source	Uncertainty (%)
Z ? tt	2-jet efficiency	10
	Jet energy scale	29
WW/WZ	MC Generator	40
	Jet energy scale	18
DY (ee, mm)	Method	98
	Jet energy scale (H_t)	20
Fakes	Method	32
	Different Jet Samples	8

Background check: 0, 1 jet bins

- Cross-check our background predictions in regions with no top signal

Source	N jets	
	0j	1j
WW/WZ	12.4 ± 5.4	3.3 ± 1.4
Drell-Yan	4.4 ± 2.0	2.2 ± 1.1
$Z \rightarrow \tau\tau$	0.20 ± 0.06	0.87 ± 0.25
Fakes	5.53 ± 1.14	4.35 ± 0.90
Total Background	22.5 ± 5.90	10.7 ± 2.1
$t\bar{t}$ ($\sigma = 6.7$ pb)	0.1 ± 0.0	1.4 ± 0.2
Total SM expectation	22.6 ± 5.90	12.1 ± 2.9
Run II data	19	11

Signal region

- We measure the cross-section after H_T & OS

Source	N jets			
	0j	1j	$\geq$ 2j	H_T, OS
WW/WZ	12.4 ± 5.4	3.3 ± 1.4	0.83 ± 0.36	0.50 ± 0.22
Drell-Yan	4.4 ± 2.0	2.2 ± 1.1	0.7 ± 0.4	0.44 ± 0.44
$Z \rightarrow \tau\tau$	0.20 ± 0.06	0.87 ± 0.25	0.69 ± 0.20	0.43 ± 0.12
Fakes	5.53 ± 1.14	4.35 ± 0.90	2.47 ± 0.52	1.07 ± 0.35
Total Background	22.5 ± 5.90	10.7 ± 2.1	4.7 ± 1.8	2.4 ± 0.7
$t\bar{t}$ ($\sigma = 6.7$ pb)	0.1 ± 0.0	1.4 ± 0.2	8.8 ± 1.2	8.3 ± 1.2
Total SM expectation	22.6 ± 5.90	12.1 ± 2.9	13.5 ± 2.1	10.7 ± 1.4
Run II data	19	11	14	13

Results per dilepton category

Source	Events per 193 pb^{-1} after all cuts			
	ee	$\mu\mu$	eμ	$\ell\ell$
WW/WZ	0.15 ± 0.07	0.12 ± 0.05	0.22 ± 0.10	0.50 ± 0.22
Drell-Yan	0.35 ± 0.28	0.09 ± 0.34	-	0.44 ± 0.44
$Z \to \tau\tau$	0.09 ± 0.03	0.11 ± 0.03	0.23 ± 0.07	0.43 ± 0.12
Fakes	0.30 ± 0.10	0.15 ± 0.05	0.62 ± 0.22	1.07 ± 0.35
Total Background	0.9 ± 0.3	0.5 ± 0.4	1.1 ± 0.3	2.4 ± 0.7
$t\bar{t}$ ($\sigma = 6.7$ pb)	1.9 ± 0.3	1.8 ± 0.3	4.5 ± 0.6	8.3 ± 1.2
Total SM expectation	2.8 ± 0.5	2.3 ± 0.6	5.6 ± 1.0	10.7 ± 1.4
Run II data	1	3	9	13

Data Candidates

- 10 candidates:
  - ee: 1 events
  - eμ: 9 events
  - μμ: 3 events
- Only one has a nonisolated lepton

ee

TCE/TCE

mm

CMUP/CMP

CMUP/CMX

CMX/CMX

eμ

CMUP/NITCE

TCE/CMUP

TCE/CMP

TCE/CMU

TCE/CMX

TCE/CMX

TCE/CMX

TCE/CMIO

PHX/CMUP

Cross Section

$$\sigma(t\bar{t}) = \frac{N_{obs} - N_{back}}{\varepsilon \times A \times \int L dt}$$

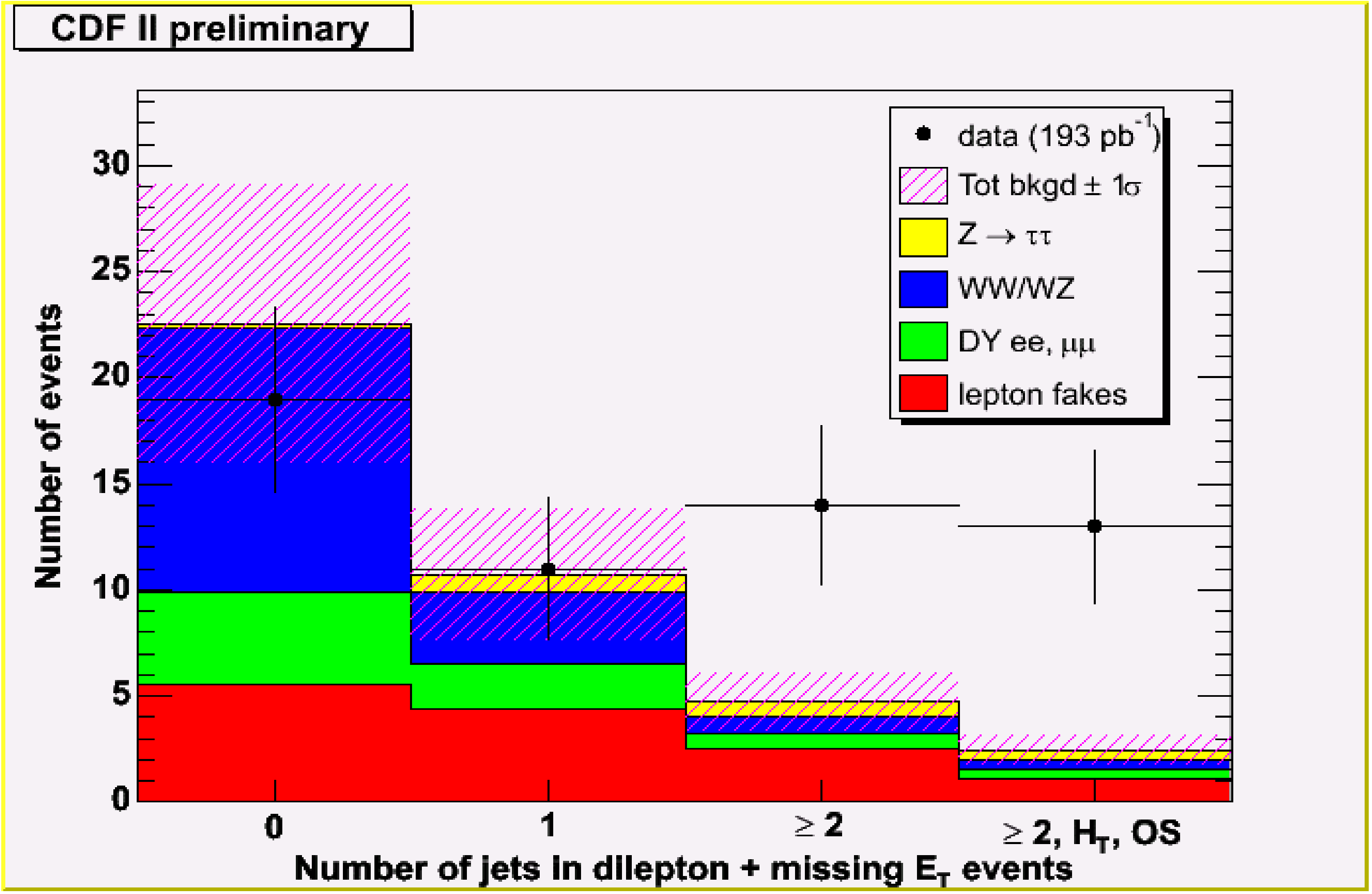
$$\varepsilon \times A \times \int L dt = (1.23 \pm 0.17)\, pb^{-1}$$

- Winter'04 Preliminary:

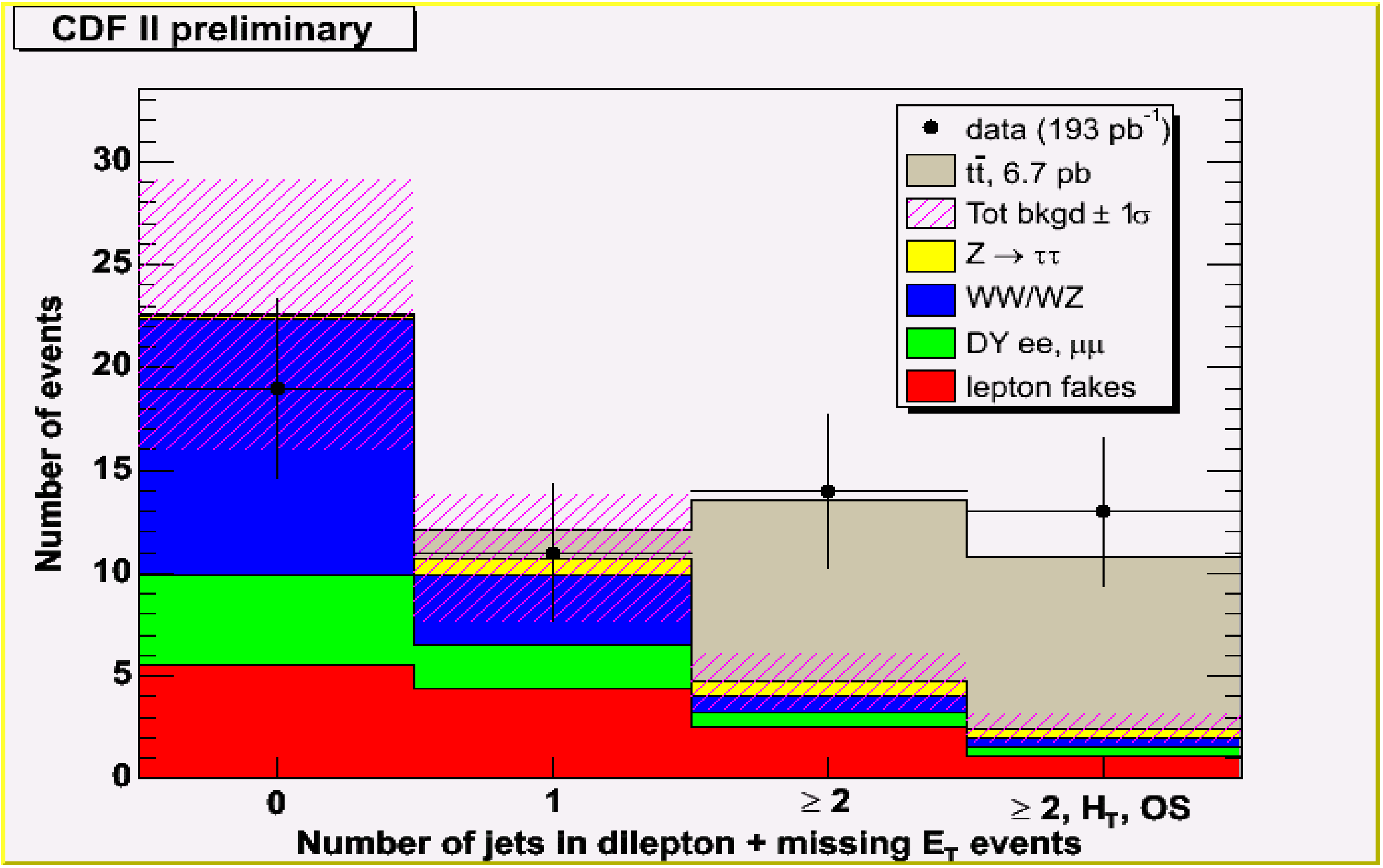
$$\boxed{\sigma_{t\bar{t}} = 8.6 \pm 2.9(stat) \pm 1.6(syst) \pm 0.5(lum)\, pb}$$

- Theoretical prediction: σ = (6.7 +/- 0.5) pb

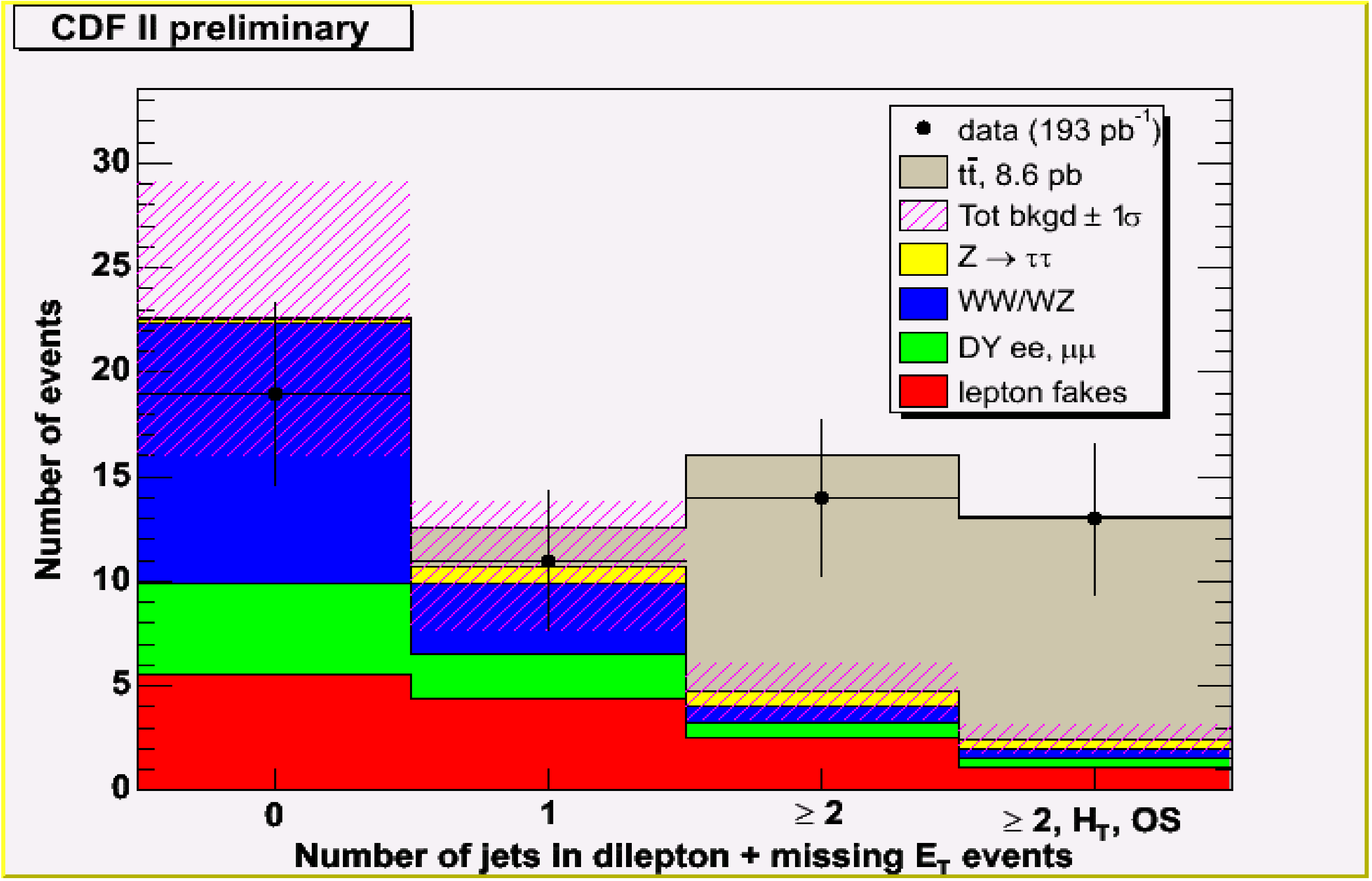
Njet plot – backgrounds only



Njet plot – BG+SIGNAL (6.7 pb)



Njet plot – BG+SIGNAL (8.6 pb)



Conclusion

- We have measured the ttbar dilepton cross-section with 193 pb^{-1}
- Our analysis has a high purity: S/B = 4
- Preblessing next week
- To do:
  - Cross-checks will be performed till next week
  - PR Plots
- Other analyses are waiting to further use this data sample (top mass, kinematic tests)
- Move toward publication next